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U.S. Army Aberdeen Test Center Light Armor Range Complex

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The U.S. Army Aberdeen Test Center (ATC) at Aberdeen Proving Ground, Maryland, is the U.S. Department of Defense's lead agency for land-combat, direct-fire, and live-fire vulnerability testing. Adjacent to the Chesapeake Bay and 35 miles northeast of Baltimore, ATC is a multipurpose test center with diverse capabilities and has become a world-class testing and training range that ensures American warfighters receive superior materiel and technology *(Figure 1)*.

One of the many testing capabilities at ATC is the Light Armor Range Complex (LARC). The LARC was built in the 1940s to support testing for the war effort and has provided support to every U.S. war and military conflict since its construction.

History of ATC and the LARC

ATC dates its beginning back to World War I, when artillery testing was moved to the new proving ground from Sandy Hook, New Jersey, to accommodate the increased volume of work and the wartime congestion of New York Harbor. Initially known as the Proof Department, the organization tested only artillery until 1923 when it created two main divisions of ordnance and automotive testing. This structure remained in effect until 1942. Expansion during World War II brought the Proving Center, which became the Ordnance Research and Development Center in 1943.

In 1945, the Ordnance Research and Development Center reorganized into the Development and Proof Services. In 1962, the U.S. Army Test and Evaluation Command was established and its headquarters located at Aberdeen Proving Ground. The test mission and facilities, along with the expertise of the workforce, continued to expand, and in 1968, the Development and Proof Services was renamed the Materiel Testing Directorate. In July 1984, Combat Systems Test Activity was activated as an independent organization within the Army Test and Evaluation Command and was renamed Aberdeen Test Center in 1995.

The LARC was constructed circa 1940s to support the developmental and acceptance testing of armor, weapons, and combat vehicles in support of World War II *(Figures 2 and 3)*. The original complex included three enclosed ranges, seven outdoor ranges, two loading rooms, and three storage rooms to support firing operations.

Traditionally, the workload at the LARC consisted primarily of testing armors for relatively few heavy armored vehicles. Approximately10 years ago, however, the Army and U.S. Marine Corps moved to field lighter and more deployable combat vehicles, which increased the workload at the LARC and strained the capability of the three indoor ranges. During the past 4 years, combat experiences in Operations Iraqi and Enduring Freedom have led the Army and Marine Corps to place an emphasis on armoring nearly all of its tactical and combat vehicle fleet. As a result, the vehicular armor testing workload, as well as personal armor protection testing workload, at the LARC has grown exponentially. Recognizing this growth, ATC set out to bring additional capabilities to the LARC.

Range upgrades

In fiscal year 2007, the LARC comprised three indoor ranges. In fiscal year 2008, ATC more than doubled the range capacity by adding four more indoor

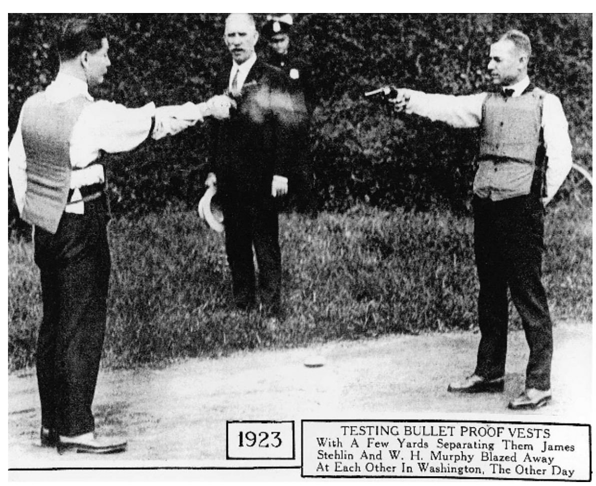

Figure 1. In 1923, two men showcase the survivability of their bullet proof vests in a publicity stunt near Washington, D.C.

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Figure 2. A plate being cooled with carbon dioxide before an armor acceptance test in 1962

firing lanes and refurbishing one of the original legacy ranges.

The cornerstone of the LARC upgrades is the four new state-of-the-art indoor ranges, D1–D4. These ranges are designed to provide maximum versatility for indoor armor testing. Traditionally armor targets were tested indoors, whereas vehicles were tested on outdoor ranges. However, ATC recognized that greater test efficiencies could be achieved by moving small arms vulnerability testing of vehicles indoors. As such, the ranges measure 12 feet high, 20 feet wide, and 100 feet long and can accommodate small tactical vehicles such as HMMWVs.

The weapon and target mounts in the new ranges also are designed for test efficiency. Weapons are placed on a mount that enables vertical elevation to be changed with the push of a button. Target fixtures are designed to allow quick and easy adjustments to obliquity, vertical displacement, and horizontal displacement. For larger targets, such as vehicles, the weapon can be mounted on a rail system that enables traverse and elevation changes to be made quickly and effortlessly. The target itself can be placed on a portable turntable that enables attack azimuths to be changed easily.

To provide protection from the noise, blast, and fragments generated during ballistic testing, the interior of the new ranges are layered with AR500 steel capped by 2 inches of ballistic rubber in the form of easily replaceable 2-feet by 2-feet panels. For targets and/or projectiles for which extensive fragmentation is expected, additional shielding can be put in place. At the end of the range is an enclosed 20-feet-long reinforced concrete and sand bullet trap. The net effect of this construction is a range that is equipped to handle up to 30-mm armor piercing projectiles.

Figure 3. In 1967, two workers set up a plate for an armor acceptance test

Of particular concern at the LARC is the ability of the tester to control the temperature and humidity of the test environment. Control of the test environment is now a requirement for many standardized armor test procedures used by the U.S. Department of Defense (DOD), National Institute of Justice, and NATO. These procedures are applicable to both personnel and vehicle armor testing.

The heating, ventilation, and air conditioning system at ranges D1–D4 is a fully automated controlled system. The ranges can be adjusted to any environmental standard set by the customer for their testing needs. The control system is able to maintain indoor climate conditions of 50 percent plus or minus five percent humidity and 68 degrees plus or minus one degree. The control system uses multiple sensors throughout the range, with the primary sensing location down range at the target area. The ability to so accurately control and monitor the temperature and humidity is vital during testing to ensure a valid test.

The heating, ventilation, and air conditioning system also has an elite, closed-loop filtration system. There are two units per range, and there are a total of 24 filters for each range. The filters collect particulate matter such as lead from the air. The pre-filters are changed every 30 days during firing operations, and the HEPA filters are changed every 90 days. Fresh air is continuously circulated to rid the range of fumes.

Test operations for the new ranges are controlled from the test control buildings that are attached to the ranges. The control building houses the ammunition storage and loading room, test control rooms, and a workshop for target preparation and fixture fabrication. Although test efficiency and capability were prime considerations in the design of this state-of-the-art facility, the concept and design of ranges D1–D4 also placed an emphasis on the needs of the customer. As such, real-time viewing of the test event is provided via multiple video monitors in the control room. In addition, the control building houses a conference room for immediate review and discussion of test events and an office space *(Figure 4)*.

Figure 4. One of the new state-of-the-art indoor firing ranges at the Light Armor Range Complex

Instrumentation

ATC test directors at the LARC use various testing instrumentation based on customer requirements. Striking velocity, residual velocity, threat pitch and yaw, threat-target interaction, and behind-armor effects are some of the data elements that may be needed during armor testing. Each test that comes to ATC has its own unique requirements, and ATC test directors work with customers to ensure their testing needs are fulfilled by using a spectrum of instrumentation, technology, and testing knowledge and experience.

Velocity can be measured through a variety of ways. Typically, optical screens and electronic counters are used to determine an instrumental velocity from which a striking velocity is calculated. The system used at the LARC is a double redundant system that uses two sets of optical screens and counters that independently calculate the projectile velocity. A computer program compares the two velocities, ensures they are within 10 feet per second of each other, averages the velocities, and calculates a striking velocity.

If additional data are desired, such as pitch and yaw for example, then ATC has a variety of digital, high-speed video, and flash X-ray systems that can provide the required data. The digital, high-speed cameras used can capture 6,688 frames per second (fps) full resolution and up to 100,000 fps at lower resolutions. X-rays, along with digital image correlation, can provide a three-dimensional reconstruction of the event, enabling critical test data to be gathered.

The laser scanner and associated software is a new technology at ATC. The laser scanning device is used to measure the surface of a material before and after an event. This provides the ability to measure post-shot data on any target and creates a three-dimensional profile of any deformations.

Temperature conditioning chambers are used to prepare the targets to meet customer specifications. Targets can be heated or cooled for any length of time to simulate different conditions.

ATC has the capability to turn around the electronic data gathered from a test that has been verified and validated to authorized customers within a 24-hour period, or 1 business day, so that the customer may make critical testing decisions.

LARC operations

The entire purpose of testing at the LARC is to save lives. How is it possible to ensure that the items we test meet and exceed the standards while setting a wartime testing pace? The LARC in action requires a staff of 20 employees working in two shifts, 6 days a week and working through holidays to keep up with the demand and pace of our customers and the warfighter's needs. The LARC staff currently tests body armor, helmets, armor plate, armor protection kits for vehicles, composites, glass, and ceramics.

Body armor, helmet research, and vehicle armor testing, all top DOD priorities, are being conducted year-round and are expected to continue. In addition, armor production acceptance testing has increased significantly because of accelerated production schedules to meet armor plate demands for the Global War on Terrorism.

On a daily basis, armor mills and manufacturers send samples of their armor to ATC for ballistic acceptance testing. These sample plates are representative of armor lots produced by the mill. Testing is conducted by ATC to assure that the product quality conforms to the specified military technical characteristics and to detect any deteriorations of quality.

During testing, small arms projectiles and fragment simulating projectiles are fired against the armor to determine the V50; i.e., the statistical velocity at which the threat projectile will defeat the armor 50 percent of the time. The threats that are fired and the required V50 that the armor must pass are based on the type and

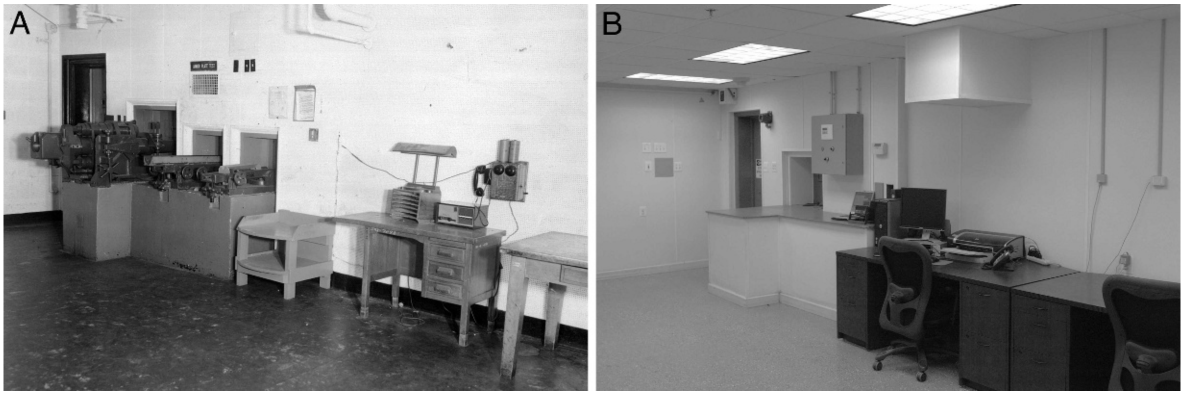

Figure 5A. The control room for legacy range D6 in 1958. 5B. The control room for legacy range D6 in 2008

thickness of the armor and are specified in applicable military standards. Results of the testing are sent to the mill. If the plate(s) successfully completes testing, then the lot of armor represented by the plate(s) is considered ballistically certified by the Army and can then be shipped to manufacturers for use.

The armor acceptance workload has increased dramatically at ATC. More than 5,000 tests have been completed so far this year, which is roughly a 500 percent increase over historical numbers. Because the supply of certified armor is so critical, ATC sets a goal of having plate tested within 2 days of its arrival at the LARC.

Other testing programs at the ranges are always ongoing. At any point, there could be a vehicle undergoing small arms exploitation testing on one range, helmet testing on another, and an armor research and development occurring on a third range.

Future direction

Nearly every future vehicle system will require armor testing at the LARC, and current vehicle systems also will continue to have armor tested at the LARC to arrive at lighter, more efficient solutions. Whereas testing of personnel protective armors was traditionally a relatively small part of the LARC workload, that is no longer true. Like vehicle armor testing, testing of personnel armor systems at the LARC also has increased dramatically. This is because of increased testing of current armor systems, in addition to increased testing of newer, improved armor technologies for future systems. The workload is expected to remain high as quality assurance testing of the new armor systems will be required once production begins.

Additional workload also is expected as the DOD looks to develop improved personnel armors as well as new methodologies and instrumentation to conduct the testing. As a result of this increased workload, ATC is constructing four additional test ranges designed to facilitate the testing of personnel armors.

In fiscal year 2005, the LARC consisted of three World War II era indoor firing ranges. Today it consists of four new state-of-the-art indoor firing ranges and one upgraded legacy range. In the near future, the LARC will consist of four more new state-of-the-art indoor firing ranges and an upgrade of the final two legacy ranges. This 11-indoor-firing-range complex will enable the LARC to meet all of the DOD's needs and requirements *(Figures 5A and B)*.

With the four new ranges, the LARC will be able to provide the full spectrum of indoor personnel and vehicle armor testing. Although the legacy and newer ranges are designed for specific applications, they also are designed to be versatile enough to give ATC and its customers a number of options and a high degree of flexibility in matching ranges to test requirements and workload.

As new materials and threats evolve, so will testing capabilities at ATC, especially in wartime. There will be new testing methodologies developed that will transform testing, just as has occurred in the past, and ATC will continue to evolve and grow to meet the ever-changing world of armor testing. ❑

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